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The investigation of optical inhomogeneities of the multilayer mirrors

progress report

LIGO-G070203-00-Z

AdLIGO mirrors: fluctuations in the coatings may limit sensitivity

Already known mechanisms:

- Brownian (associated with acoustic losses) noise
- Thermoelastic (associated with temperature fluctuation and thermal expansion) noise

BUT some others may exist:

- Stress-release shot noise and outbursts (associated with the stress produced by film deposition)
- Optical breakdown precursors (associated with powerful optical field inside the outer coating layers)

Basic ideas

1. Direct noise measurement is an **ultimate way**.

   Problem: Complete high-sensitive setup (including isolation from seismic and other noise sources) is necessary.

   Solution: Application of small mirrors aiming to have larger response on any mechanical excitation.

   Up to date progress: Our new installation isn't commissioned yet.

But AdLIGO is in urgent need of information!

Basic ideas

2. It **will be** possible to get preliminary estimations if some *reasonable* assumptions would be made:

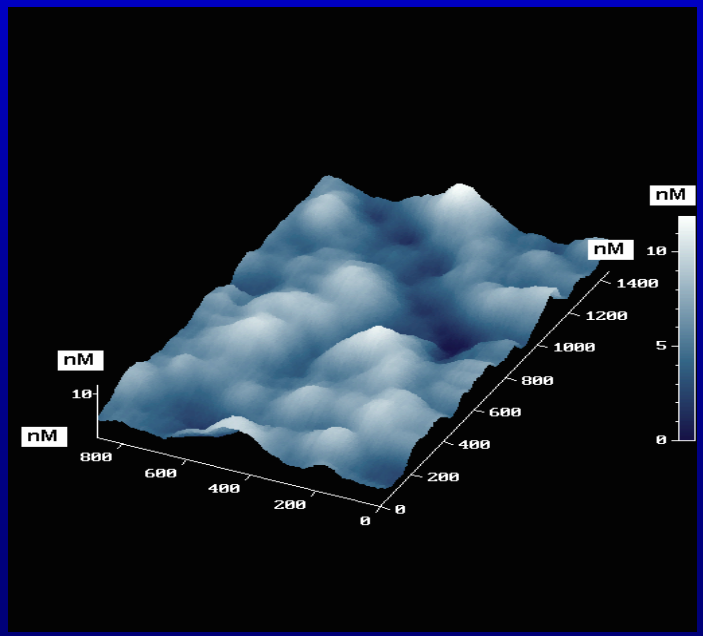
- Multilayer structure has defects.
- These very defects adsorb and scatter substantial part of light adsorbed and scattered by the structure (responsible for the additional optic loss)
- These very defects adsorb and scatter substantial part of elastic energy adsorbed and scattered by the structure (responsible for the additional mechanic loss)
- Adsorption of optic energy and concentration of elastic energy on these defects are the possible sources of additional mechanic fluctuation.

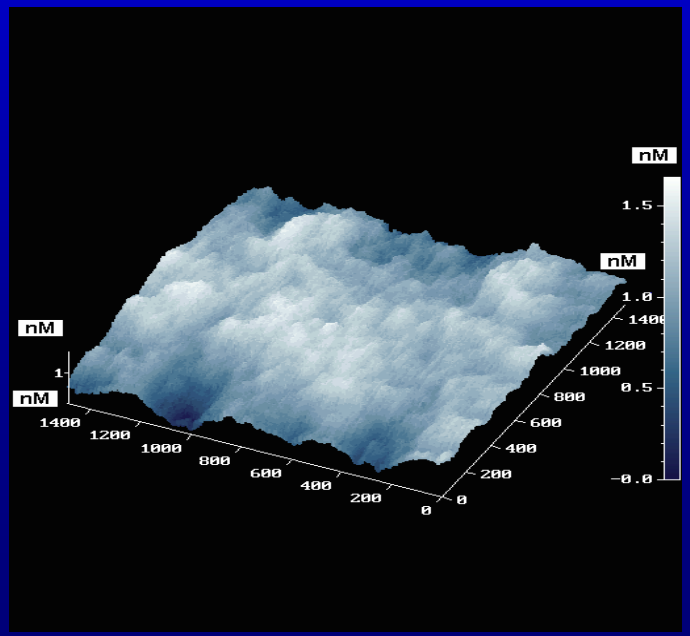
Information about quantity, character and spatial distribution of defects is required!

Some efforts already have been made:

Damage Threshold Measurement and Surface Contamination Monitoring projects are in progress (Dave Reitze, see LIGO-G050360-00-R)

Surface profile of mirror surface on deep polished and superpolished substrates made by ATM (e.g. I.Bilenko, reported on March 2006 Caltech seminar)





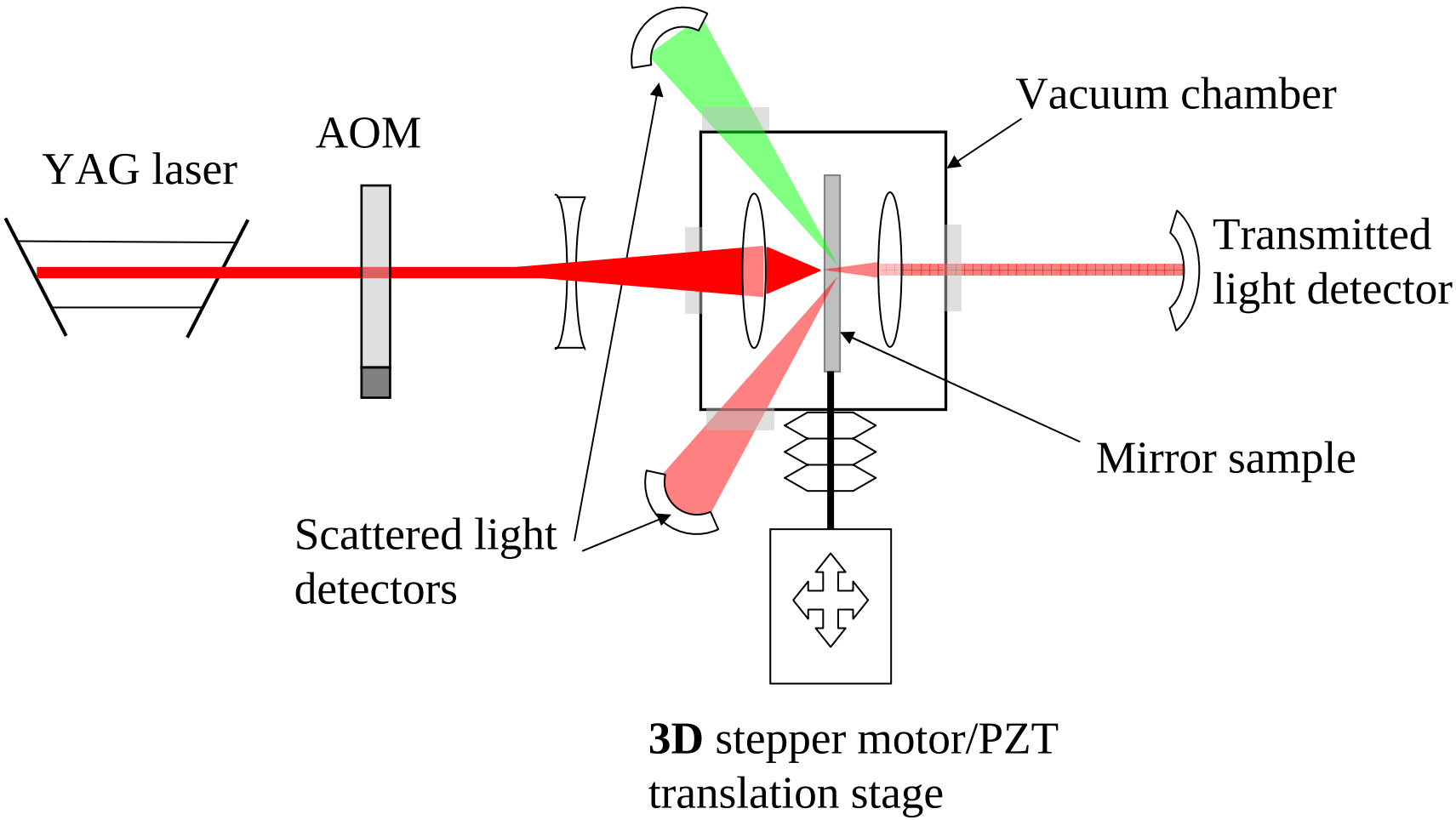
Our approach:

- Use high focused beam (about few microns waist) to obtain high spatial resolution and reach high (>10 kW/cm^2) optical power density with 100 mW YAG *without FP*.
- Measure transmission (scattering, second harmonic intensity? defocusing?? Etc???) as a function of coordinates and power.

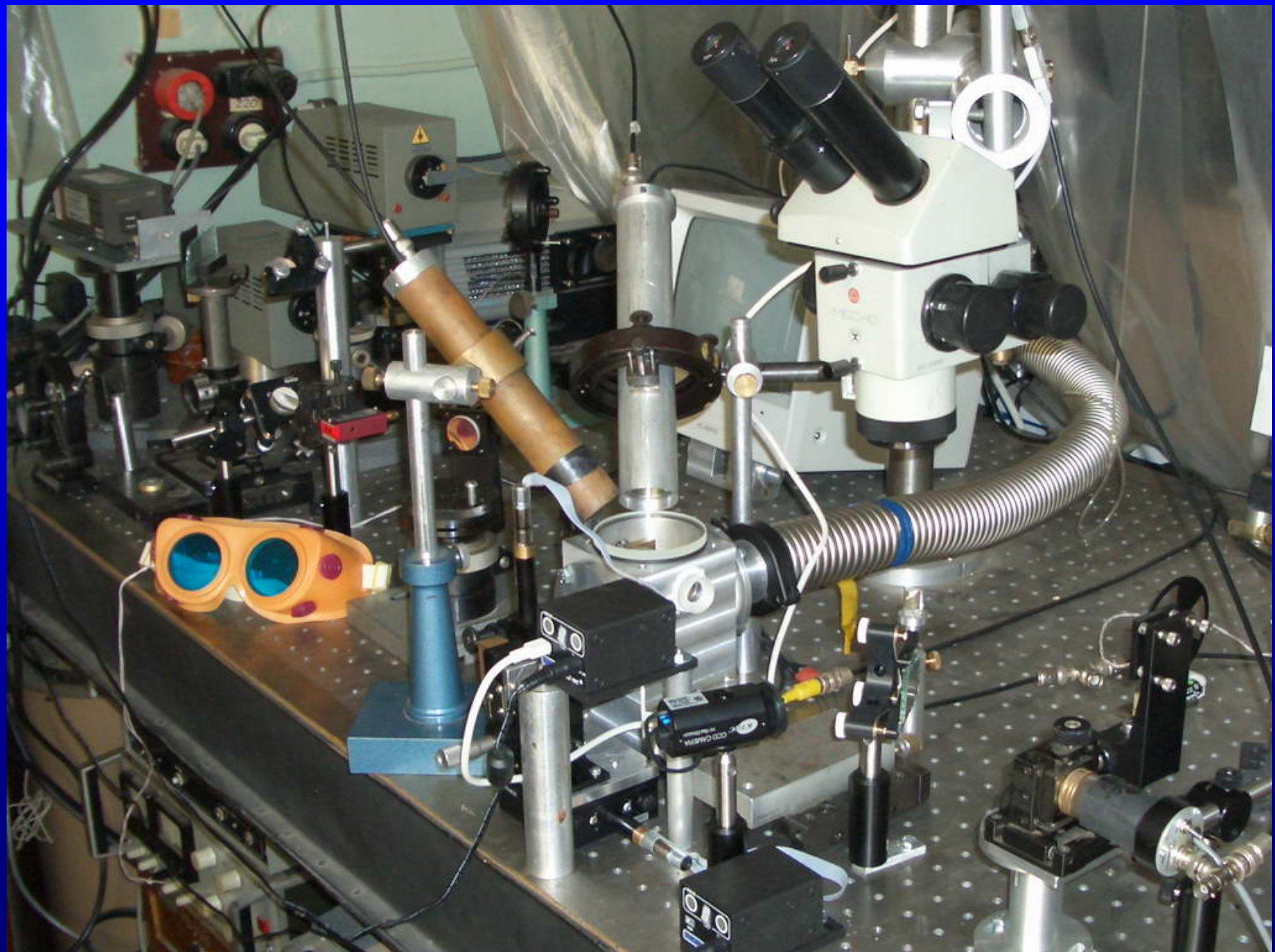
Basic parameters of the installation:

- Scan area: 20 μm x 2 mm
- Resolution: <2 μm
- Scan time: <5 min
- Transmission measurement accuracy: <1%
- Vacuum: $<10^{-4}$ Torr

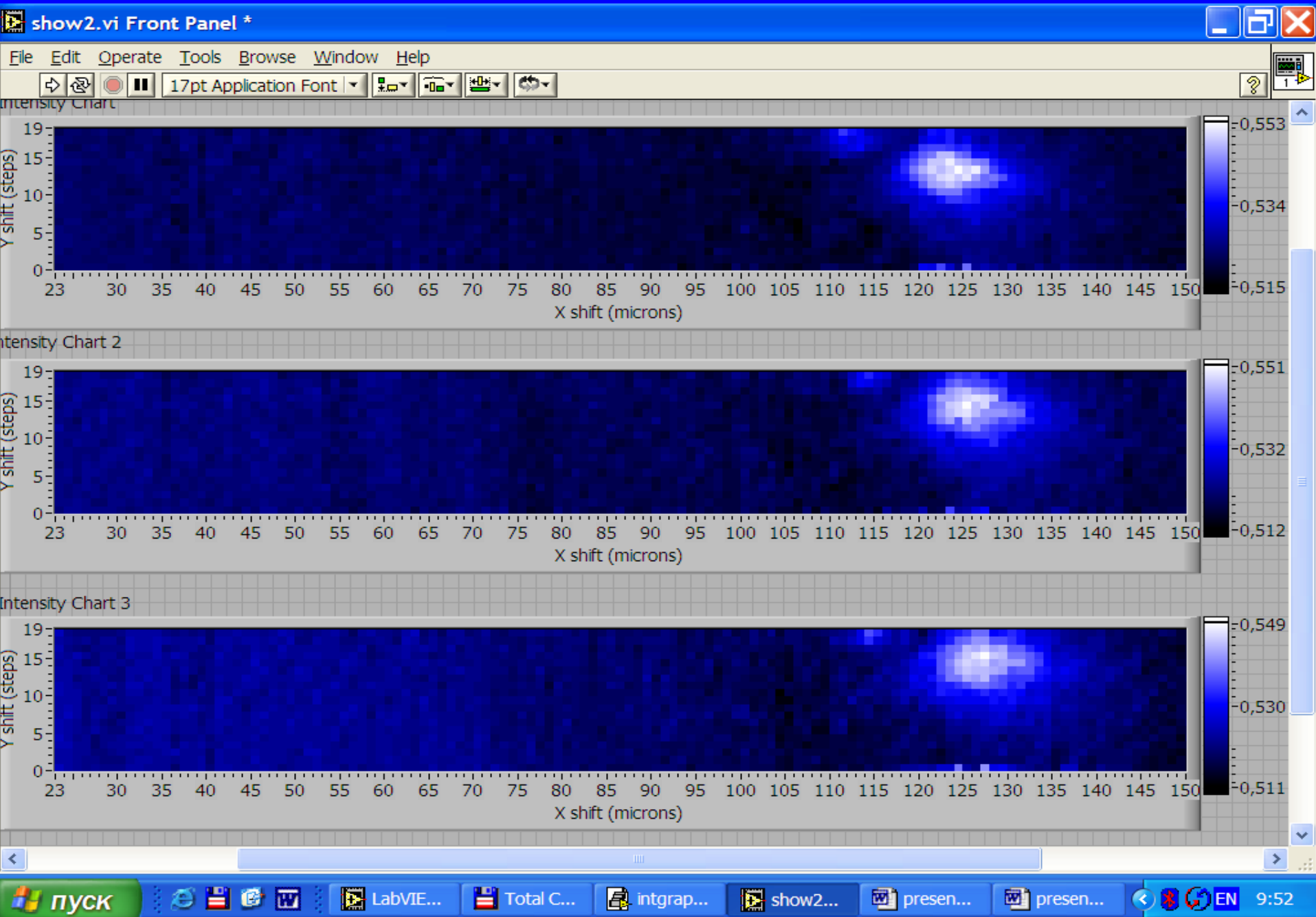
Installation diagram



Installation picture



Preliminary measurements (transmission vs position)



Conclusions

- High resolution scan is a promising approach for mirrors tests and comparisons
- Main problem: how to distinguish surface defects (scratches, **specks of dust**) from the inner ones? (apply 3D scan instead of 2D?)
- It is necessary to estimate an impact of the observed microstructure on the AdLIGO mirror performance.